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Dynamics of Solitary Wave Pulses Near the Zero-dispersion Wavelength in Optical Fibers

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13. ABSTRACT *(Maximum 200 words)*

A theoretical study was made of the propagation characteristics of solitary wave pulses near the zero-dispersion wavelength (ZDW) in optical fibers. A variety of solitary wave profiles are possible near the ZDW and some of them are found to be stable to perturbations. These findings might prove of some technolgical significance in long-distance communications, as second-order dispersion vanishes at the ZDW so the newly discovered solitary waves, which are of shorter duration than the usual solitary waves in the anomalous dispersion régime, could be utilized to increase the transmission bit rate.

14. SUBJECT TERMS
Optical fibers, long-distance communications, solitary pulses, stability, nonlinear dynamics

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1. Objectives

The main objectives of this project are:

(a) To examine the nature of solitary wave pulses close to the zero-dispersion wavelength (ZDW). This includes the question of existence of such pulses and their stability to frequency and amplitude perturbations.

(b) To explore the possibility of using these waves in soliton-based long-distance communication systems. This calls for a study of the robustness of such pulses in the presence of perturbations caused by attenuation, birefringence, the Raman effect, as well as non-uniformities along the fiber.

2. Status of Effort

We have studied the effects of higher-order dispersion on NLS solitary wave pulses (in the anomalous dispersion regime away from the ZDW) of relatively short duration. It turns out that such pulses emit radiation which, however, cannot be described accurately by the NLS equation and its extensions.

The radiation of tails is caused by a resonance mechanism that lies beyond all orders of the usual multiple scale expansion leading to the NLS equation, and a procedure for calculating these tails using exponential asymptotics has been devised. Despite having exponentially small amplitude in the asymptotic sense, the radiated tails can be significant when dealing with pulses of relatively short duration.

3. Accomplishments/New Findings

The existence of solitary waves near the ZDW and the fact that these waves are, according to all indications, not unstable (contrary to opposite claims made in previous work) might prove of some technological significance in long-distance communications. Because second-order dispersion vanishes at the ZDW, the newly discovered solitary waves are of shorter duration than their NLS counterparts (with the same peak amplitude), and they could be used to increase the transmission bit rate. Moreover, understanding the radiation emitted by relatively short NLS solitary wave pulses in the anomalous dispersion regime should be beneficial in controlling this radiation and thereby reducing noise.

4. Personnel Supported

Faculty: None

Post-Docs: None

Graduate Students: D.C. Calvo

Other: None

5. Publications

D.C. Calvo & T.R. Akylas, "On the formation of bound states by interacting nonlocal solitary waves", *Physica D* **101**, 270–288, March 1997.

D. Calvo, 1997 Dynamics of Nonlinear Pulses Near the Zero-Dispersion Wavelength in Optical Fibers. MS thesis, Department of Mechanical Engineering, MIT.

D.C. Calvo & T.R. Akylas, "Stability of bound states near the zero-dispersion wavelength in optical fibers", *Physical Review E* **56**, 4757–4764, October 1997.

D.C. Calvo & T.R. Akylas, "Do envelope solitons radiate?", *Journal of Engineering Mathematics* **36**, 41–56, July 1999.